Country Club Lawn and Tree Specialists Inc.

Risk Assessment & Mitigation Manual

Contents

Introduction

This document is meant to utilized for both multi-ship and single-ship operations.

Purpose

This document is intended to set the conditions and culture for The Operator to operate safely within the FARs and approved FAA waivers. Leadership is committed to a healthy safety policy and culture that identifies risks and takes prudent steps to mitigate them. In this manner while there might be an office or individual assigned to focus on safety that does not alter the expectation that any member of the team be vigilant and forthright when it comes to identifying risks and being a safety officer. It outlines how to identify hazards to operations and mitigation strategies. It also serves as guidance for using all available information to craft a mission plan that functions at an equivalent or safer level than FAA rules.

Sources

The primary source for aviation safety management and risk management information is the FAA's safety management system manual (April 2019) (https://www.FAA.gov/air_traffic/publications/media/ato-SMS-manual.pdf). While it is written for an air traffic organization, it does an excellent job of articulating the risk identification and assessment process as well as addressing the attributes of a healthy climate and supportive safety policy.

The other source for risk management reference is the FAA Risk Management Handbook. (https://www.FAA.gov/regulations_policies/handbooks_manuals/aviation/media/FAA-h-8083-2.pdf) This provides an excellent operational perspective.

Philosophy

The four components of the safety management system (SMS) combine to create a systemic approach to managing and ensuring safety. These components are:
- Safety Policy: the documented organizational policy that defines management's commitment, responsibility, and accountability for safety. safety policy identifies and assigns responsibilities to key safety personnel.
- Safety Risk Management (SRM): a process within the SMS composed of describing the system; identifying the hazards; and analyzing, assessing, and controlling risk. SRM includes processes to define strategies for monitoring the safety risk of the national airspace system (NAS). SRM complements safety assurance.
- Safety Assurance: a set of processes within the SMS that verify that the organization meets or exceeds its safety performance objectives and that function systematically to determine the effectiveness of safety risk controls through the collection, analysis, and assessment of information.
- Safety Promotion: the communication and distribution of information to improve the safety culture and the development and implementation of programs and/or processes that support the integration and continuous improvement of the SMS within the organization. Safety promotion allows the organization to share and provide evidence of successes and lessons learned.

Risk Matrix

As outlined in the FAA SMS manual, risks need to be assessed to help leadership make decisions about prioritization and mitigation. A common way to articulate this matrix is depicted in the figure below where likelihood of a mishap due to the unmitigated risk is arranged with respect to the severity of a potential mishap due to the same unmitigated risk. Where the two intersect the figure labels the risk as low, medium, and high.

Severity / Likelihood	Minimal 5	Minor 4	Major 3	Hazardous 2	Catastrophic 1
Frequent A	Low	Medium	High	High	High
Probable B	Low	Medium	High	High	High
Remote C	Low	Medium	Medium	High	High
Extremely Remote D	Low	Low	Medium	Medium	High
Extremely Improbable E	Low	Low	Low	Medium	High* / Medium

*Risk is high when there is a single point or common cause failure.

Methods

Ground Crew

The ground crew will consist of a PIC (for small and simple single vehicle operations on days with nice weather for missions on familiar ground). As complexity increases a crew of up to 4 may be utilized for a four-ship of UASs operating on challenging ground with rolling topography. The following pages illuminate more of the operations methods that The Operator will employ to achieve the desired level of safety.

Pre-Mission Worksheet

Using this architecture, the pre-mission worksheet has been constructed to assist leadership as the individual missions are planned. Decisions such as waiting for better weather, conducting an additional hazard assessment or assigning more team members present the UAS supervisor with mitigation choices. Ultimately the owner/operator can be brought in to make informed risk decisions if required. The points assigned are efforts to quantify the low, medium and high risks from the chart. As The Operator builds corporate experience in the mission set the worksheet will be updated.

Primary Incident Causes

Research for this business venture has revealed that the most mishaps have occurred due to flawed or incomplete hazard review of the target treatment parcel of land. Consequently, mapping, interviews and familiarity with the piece of land are encouraged or mandated to mitigate the hazards.

Risk Categories

During the operation analysis, three main risk categories were identified beyond the control of the operator; vehicle maintenance, weather and other users of the NAS.

The maintenance risk is being managed by following the Manufacturer maintenance guidance and with the PIC conducting a thorough airworthiness prefight inspection. Fortunately, the missions are not expected to place the vehicle at altitudes above 50 ft agl or greater than 5000 ft from the control station. Further the mission places the vehicle over uninhabited privately-owned cropland not structures or people and should an urgent malfunction require immediate action the PIC can land the UAS in a matter of seconds.

The risk of weather impacts both the safe operation of the UAS in the NAS and the desired effects of the pesticide. The values of the pre-mission worksheet attempt to show the relative mission risks with specific weather.

Multi-Ship (ignore unless multi-ship waiver approved)

Perhaps the two greatest waiver requests from some Operators are the desire to conduct multi-ship formation missions and for portions of missions the vehicles may be out of visual line of sight. I'll first deal with the mitigation of risks from multi-ship formations of UASs. The AgroSol software uses geographical deconfliction as depicted in the Manufacturer Operations Manual. Individual vehicle home point launch and landing coordinates must be at least 25 ft apart. It is part of the mission planning stage to deconflict the vehicles from crossing flight paths. The primary method of mitigating the risk of conflict in a multi ship formation mission is geographical. The secondary mitigation strategy is for the PIC and VO to identify potential conflicts if they observe the vehicles on converging vectors. The tertiary mitigation method is the individual vehicle obstacle detection system which will, if engaged cause the UAS to hold position or maneuver away from the conflict. This section may be disregarded for single-ship operations.

Deconfliction (ignore multi-ship sections unless multi-ship waiver is approved)

Deconfliction of the formation from other NAS users is handled by the PIC and rest of the crew. It is the intent of the ORM worksheet to drive multi-ship formation missions to have a larger crew but not necessarily one VO per vehicle. During formation operations the vehicles will be identified by their operating zones, as well as the situational awareness of the PIC and crew. If there is every any doubt about a specific UAS the PIC can be asked to have it hold position for confirmation. A system of one VO for each UAS concerns leadership that it might give the impression of more supervision than might actually be occurring. If the vehicles maneuver briefly out of line of sight perhaps by passing behind a shrub the VO may incorrectly acquire a different UAS and leave one vehicle without a dedicated observer while a different vehicle may unintentionally have more than one observer. This situation is a manifestation of a human factors risk when the crew size is arbitrarily driven by the 1:1 ration of VO to UAS. A second concern about mandated ratios is that it unintentionally creates the impression that the FAA values constant unblinking monitoring of a specific vehicle over the tried and true aviation visual look out technique of scanning the sky by briefly focusing on specific pie slices to detect movement, maintain awareness of vehicles in the assigned operating area and identify potential conflicts.

The Operator considered the idea of an ADS-B out unit on either an UAS or located at the ground station. Ultimately it was concluded that the cost significantly exceeded any benefit. While a simple ADS-B transmitter can be acquired for less than $2,000 it appeared that there would be no measurable safety benefit from doing so. Adding the transmitter to the UAS would decrease payload and reduce sortie duration. ADS-B is not required in class-g airspace, which is where nearly 100% of the UAS sorties will occur. The ultra-low altitude of the normal missions combined with the remoteness of the terrain led me to believe that the signal would very rarely be received and when received would not enhance the situational awareness of potential conflicts. The radar horizon at 15 ft (average altitude of a sortie) is 5.5 nautical miles. This means for an aircraft to have line of sight to receive the signal if it was operating below 100' agl then the aircraft would have to be within 5.5 nautical miles. Further, during discussions with the crop duster advocacy group national agricultural aviation association (NAAA), I was advised that they are not in favor of mandating ADS-B systems on their member crop dusters. They encourage such devices but acknowledged what was confirmed by the local crop dusters which is they don’t have ADS-B in their air tractors and have no plans to install it.

Ultimately the NAS users with the greatest risk of conflict to an ultra-low ag UAS have no plans to acquire systems which would provide them situational awareness on those UASs if they were equipped with ADS-B out. The low altitude environment, due to other higher priority tasks, is not one where a manned aircraft should be heads-down looking at air traffic displays. Therefore, if an ADS-B out transmitter was installed on either the UAS or at the ground station it would most likely be limited to providing conversation to en-route traffic overflying the operating area at an altitude thousands of feet above the operation.

Safety Culture

The Operator intends to achieve a parity level of safety for other NAS users by sanitizing the airspace within, above, and around the mission operating area. In this sense the operator will be using electronic means to monitor the location of the UAS and mission execution. A hotspot data link will also be providing any live radar tracking data. All of this electronic monitoring will be accessible (although not necessarily throughout the full sortie) to the ground support member and VO if those positions are required based on the risk management worksheets. The electronic situational awareness tools are intended to augment the visual scanning being done by the crew member with those responsibilities. The primary airspace being used by UAS operations is within 5000 ft of the control station and less than 20 ft agl. Unbriefed aircraft operating in this airspace is an extremely rare event. The Operator considers one of the best ways to identify the risk of an unexpected aircraft in the ultra-low environment is to have a healthy communication channel with the local crop-dusting operations.

The vital role of clearing the airspace will be accomplished by focusing on the quadrant above the mission and then clearing the adjacent areas to either side of the quadrant. The risk management worksheet delineates a simple situation where a small field can be isolated to several small pie slices of the sky. For a large field there is a larger piece of the sky that the observer must be monitoring and therefore a larger crew might be needed or the mission simplified so as to achieve the desired level of deconfliction. These clearing concepts will be updated and the training expanded to reflect lessons learned and unforeseen situations with the ultimate requirement of achieving a level of safety parity for NAS users sharing the air in the vicinity of a mission.

Ag spraying is a seasonal operation. While risks will be mitigated promptly in priority with their complexity and hazard level, this document and associated worksheets will be reviewed annually. Team members will be empowered to “knock-it-off" if unplanned or unmitigated risks are impinging on the mission.

Risk Management Analysis And Mitigation

Identify Risks and Hazards

Hazard	Cause of Hazard	Credible Outcomes	Existing Controls	Control Owner
Technical issue with UAS	mechanical software lost link GPS failure uncommanded flight	ineffective sortie due to forced landing, or early return to home	maintenance inspection pre-flight airworthiness inspection GPS points in software for flight plan GPS failure and lost link protocols for safely returning vehicle to launch area	operator and manufacturer
Support problems/limits	lose ADS-B in data lose lte cell coverage for flight radar-24 lose radio monitoring of ag frequency or CTAF lose real-time weather picture	reduced awareness of vehicle location	use redundant or overlapping airspace awareness techniques and ensure flight plans are build with the correct contingency altitudes and flightpaths	operator
Operator error	poor training poor proficiency	incorrect command resulting in failure to dispense the pesticide or causing a vehicle mishap with an unidentified obstacle	pre-mission survey, interview, mapping, and field familiarity	operator
Adverse environmental conditions/deteriorating	winds visibility ceiling	excessive pesticide drift or unable to see far enough to conduct VFR operations	thorough preflight weather briefing just like a part 91 operator does	operator
AG BVLOS	terrain in field location of launch/recovery station	near miss with unbriefed air traffic	train pic and VO on best practice visual look out techniques that have been used by aviators for decades	operator

Examples of Outcomes

Hazard	Severity	Likelihood
Technical Issue with UAS	Major	Extremely Remote
Support Problems/Limits	Major	Extremely Remote
Adverse Environmental Conditions/Deteriorating	Minimal	Probable
AG BVLOS	Minor	Remote
Operator Error	Major	Remote

Assess Safety Risk

Hazard	Initial Risk Level	Rationale
Technical Issue with UAS	Medium	Could force immediate land which could damage the vehicle
Support Problem/Limits	Medium	Might for an unplanned landing which raises risk of vehicle damage
Adverse Environment/Deteriorating Conditions	Low	even in rapidly changing conditions the vehicle is less than 2 minutes from the launch and recovery area so it can be landed promptly
AG BLVOS	Low	The PIC maintains situational awareness on the UAS via the map datalink and continues to monitor the skies for conflicts in the same manner as if the vehicle were visible
Operator Error	Medium	This has proven to be the cause of most mishaps

Safety Risk Controls & Residual Safety Risk

Hazard	Additional Controls	Severity	Likelihood	Residual Risk Level
Technical Issue with UAS	Data sharing with manufacturer, log analysis and thorough preflight	Major	Extremely improbable	Low
Support Problems/Limits	Log analysis, collaboration with manufacturer to ensure low risk flight plans and address software or logic issues	Minor	Extremely Remote	Low
Operator Error	Through training and regular safety reviews of the mission reports to identify near miss situations, conduct root cause analysis and develop improved procedures	Minor	Extremely Remote	Low

Safety Performance Monitoring & Hazard Tracking

Hazard	Monitoring Activity	Frequency	Duration	Safety Performance	Person Responsible for Monitoring
Technical Issue with UAS	Computer Logging of System performance throughout flight	Analysis Monthly, if Operators report anomalies or if defects discovered during regular pre/post flight and Recurring Maintenance Inspections	Throughout the lifecycle of the vehicle	In the case of unexplained issues suspend operations until root cause analysis determines the cause and mitigated. This will include reviewing logs and sharing data with the manufacturer engineering team	Owner/Builder
Support Problems/Limits	mission report capturing any lessons learned or near misses	Review Monthly for non-urgent items. If urgent the process will	Throughout the lifecycle of the Vehicle	In the case of unexplained issues suspend operations until	Operator/Builder

		be reviewed before the next sortie		root cause analysis determines the cause and mitigated. This will include reviewing logs and sharing data with the manufacturer engineering team	
Adverse Environment deteriorating conditions	Use part 91 mission planning weather information	Note mission impacts on the mission report Review seasonally	yearly as longs as operations continue	Evaluate operating manual criteria and change as needed	Owner/operator
AG BVLOS	Note occurrence in mission report	review mission reports monthly	yearly as longs as operations continue	Evaluate operating manual criteria and change as needed	Owner/Operator
Operator Error	Safety meetings and mishap reports	for urgent issues suspend operations until cause identified, training completed and risk mitigated	Monthly	look to identify leading indicators for use in future operations	Owner/Operator

Operations Within 500ft

For any flight operation within 500ft of a nonparticipating entity, all restrictions outlined in the CONOPS manual will be followed. In addition, the Pre-Mission Operations Risk Management Review must be completed for each mission that will be within 500 ft and up to 100ft of a nonparticipating entity.

If the point total is greater than 12, the mission will not be flown.

Appendix

Pre-Mission Operations Risk Management Review

Points	Risk
	how many times has this parcel been treated (zero=4, once =3, twice=2, three or more=1)
	is a detailed map (within past 12 months) available from a UAS mission (yes=0, no=2)
	is the parcel larger than 40 acres (yes=1, no=0)
	are structures near (500 ft) the recommended control station location (yes=2, no=0)
	is the airspace above the parcel class g (yes=0, no=3)
	is the visibility 5 statute miles or more and are the lowest clouds higher than 5000 ft agl (yes=0, no=2)
	is the wind greater than 4 mph and less than 12 mph (yes=0, no=2)
	is the projected mission time less than 3 hours (yes=0, no=1 for a 3-6 hour mission, 3 for a 6-9 hour mission, 5 for a 9-12 hour mission)
	is the parcel less than a 30 minute drive from the office (yes=0, no=1)
	how many flagged UAS hazards exist in on the parcel (#= points)
	are there environmentally sensitive areas within ½ mile of the border of the parcel (including apiary activity) yes=2, no=0
	are any active UAS notams, or other ag aero operations planned within 5 miles of the parcel? yes=3, no=0
	has the PIC led 50 UAS missions or more (yes=0, no=1)
	is bvlos expected/anticipated? (yes=3, no=0)
	how many UAS vehicles are planned to be operating simultaneously during the mission (#=points)
	is the airspace above the parcel less than ¼ of the horizon (within a 90 degree angle)? yes=1, no=3
	is a visual observer part of the crew (yes=subtract 5 points)
	is a ground support person part of the crew (yes=subtract 4 points)
	Point Total

If less than 6: the PIC can decide to launch the mission and mitigate any risks as identified

if 7-12: the UAS supervisor must make the launch decision

if greater than 12: the owner/operator must make the launch decision